Non-linear dynamics for contactless mechanical characterization of 2D materials

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The remarkable mechanical properties of 2D material membranes have sparked interest for potential uses as pressure, gas and mass sensors. For such applications it is essential to have accurate methods for determining their mechanical properties. The conventional method for determining mechanical properties (e.g. Youngs modulus and pretension) of suspended 2D materials is based on the atomic force microscope (AFM) nanoindentation technique. AFM indentation, however, requires mechanical contact between the sharp AFM tip and the membrane, which can lead to large stress and adhesion effects near the AFM tip, causing membrane fracture and complicating the theoretical analysis.

The goal of this work is to develop a fast and accurate method for determining the Young's modulus of 2D materials exploiting their nonlinear dynamics response. To demonstrate the method, we perform a series of measurements on strongly driven circular graphene and MoS_2 membranes, showing the transition from linear to nonlinear behavior. The nonlinear response is approximated by a single Duffing oscillator, and harmonic balance method together with a least squares technique is used to identify the Youngs modulus following an iterative approach.